International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Comparative Study of Bitumenous Mix Modified Using Phosphogypsum and Plastic

Cristy Varghese

Department of Civil Engineering, Viswajyothi College of Engineering and Technology,Muvattupuzha, Ernakulam, Kerala, India

Abstract: ***There has been an increase in number of vehicles with an ever increasing population and also because of the improved living conditions of people. Pavements are subjected to various kinds of loading which affects the pavement performance condition that causes various distresses. These distresses include rutting, fatigue cracking, and temperature cracking. In this study an attempt has been made to improve the bituminous mix by using phosphogypsum and plastic. This paper includes results of various laboratory test conducted on bitumen, aggregates and modified bitumen.***

Keywords: Aggregate, Bitumen, plastic bitumen-aggregate mix, Phosphogypsum bitumen-aggregate mix

1. Introduction

Most of Indian roads are flexible pavements. This is largely because these binders are of low initial cost and easiness in its availability. But due to increased heavy channelized traffic and repeated axle loads, the capability of bituminous binders is reduced resulting in rutting, pot holesand cracks during cold climate and bleeding during hot climate. Therefore it is essential to modify the bitumenin order to meet the axle load requirements and to check the pavement failure.

Urbanization and rapid industrialization directly contributes to waste generation and unscientific waste handling causes health hazards and urban environmental degradation. Increased waste generation and non-availability of adequate methods for safe disposal of these waste is a serious concern all over the world. This plastic (PL) waste which is non-biodegradable either get mixed with Municipal Solid Waste and/or thrown over land area and it causes serious environmental impact. Thus an alternate use of waste plastic is necessary. Softened plastic have a binding property and can be mixed with binder like bitumen to enhance this property. This is a good modifier for the bitumen, used for road construction.

Phosphogypsum (PG) is the by-product of the production of fertilizer from phosphate rock. This by-product is mostly disposed of without any treatment, usually by dumping in large stockpiles. PG occupy large land areas and cause serious environmental damage. It could be effectively managed by treating with bitumen as modifier.

2. Literature Review

Aggregates are the most important material for the pavement construction. Basically aggregates are classified into coarse aggregates, fine aggregates and mineral filler based on their sieve size. Coarse aggregates are those which retain on 2.36 mm sieve. Fine aggregate pass through 2.36 mm sieve and retaining on 0.075 mm sieve and mineral aggregates pass through 0.075 mm sieve. Aggregates should possess sufficient strength to resist wear and tear, crushing and stress due to traffic wheel load. Moreover it should be hard enough to resist the abrasive action caused by the movement of traffic. In this study, 10mm, 20mm size aggregates and quarry dust were used. It was collected from a local quarry near Thodupuzha. The aggregate tests conducted includes sieve analysis, aggregate crushing, impact value test and shape test.

Figure 1: 20mm size aggregates

Bitumen act as a binder of the aggregate that ensures the structural strength and texture of the road surface.It gives the road surface elasticity, a characteristic that has led bituminous road surface to be known as flexible pavements. Bitumen of Viscosity Gradient (VG) 30 bitumen was used in this study. Bitumen was collected from MA College, Kothamangalam. The basic test conducted on bitumen include softening point test, ductility test and penetration test.

Figure 2: VG 30 Bitumen

Plastic is widely used in pavement construction due to its flexibility, strength between aggregates and bitumen. Concept of utilization of waste plastic in the construction of pavement has shown better resistance to water which reduces the stripping of bitumen from aggregate. The softened plastic have a binding property. However plastic materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This is a good modifier for the bitumen, used for road construction. Granular plastic is used in this study and this was collected from Sona Polymers, Kalamaserry. The plastic was of HDPE (High density polyethylene) category

Figure 3: HDPE Plastic

PG is not widely used in construction of pavement due to its chemical nature and moreover it is less known compared to plastic. This study also aim to analyse the result when PG was added to bitumen and compare the results obtained from plastic and PG modified bitumen separately.

Figure 4: PG

3. Research Methodology

The research methodology for the present study has adopted various tests to investigate the results on aggregates, bitumen and modified bituminous mix(plastic aggregate bitumen, PG aggregate bitumen).

The tests include softening point test, ductility and penetration were conducted on bitumen and modified bitumen. The aggregates were proportioned for MarshallStability test. To design the bituminous mix, the MarshallStability test was conducted for normal bitumen and modified bitumen using PG and plastic.

Aggregate Proportioning
Amount of aggregates for MarshallStability test was done by Trial and error method. The total weight of aggregate was found out from MoRTH (Ministry of Road Transport and Highways), by the formula: (%finer of 20mm*X) +(%finer of 10mm*Y)+ (%finer of quarry dust*Z).
Where,
X – Weight of coarse aggregate of 20mm.
Y – Weight of coarse aggregate of 10mm
Z – Weight of quarry dust
Therefore by substituting X= 0.14 ,Y = 0.37 and Z=0.49 ,we get the weight of 20mm aggregate as 168g, 10mm aggregate as 444g and quarry dust as 588g.

Marshall Method of Mix Design
The Marshall Stability and flow test provides the performance prediction measure for the Marshall Mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute. Load is applied to the specimen till failure, and the maximum load is designated as stability. During loading, an attached dial gauge measures the specimen's plastic flow (deformation) due to the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load is recorded.

Specimen Preparation
1200gm of aggregates were heated to 160 degree Celsius. Bitumen was also heated to the same temperature. Modifiers were added to the aggregates (dry process).The bitumen was added to the above mix and thoroughly mixed.

The mix was placed in a preheated mold and compacted by a rammer with 75 blows on either side. The test specimen was extracted the next day. The specimen was water cured at 60 degree Celsius for half an hour.

The bitumen content was varied (5%, 5.5%, 6%)to find the OBC. The above procedure was repeated with varied percentage of modifiers (5%, 7.5%).The prepared mold is loaded in the Marshall Test setup .The proving ring reading and the dial gauge reading was noted down.

Figure 5: Heating of aggregates

Figure 6: Marshall stability specimen

4. Results and Discussions

Laboratory Tests on Aggregates
Basic tests were conducted on aggregates to determine the material characteristics and properties of aggregate material for use in pavement construction. The basic tests include impact test, aggregate crushing, sieve analysis and shape test.

Following are the tests conducted on laboratories

Impact Test (IS:2386 Part IV -1963)
Toughness is the property of a material to resist impact. During traffic load and intensity, the aggregates are subjected to various actions and it lead to breaking of aggregates into smaller pieces. Thus the road stones should be tough enough to resist fracture under impact. This test is done to determine the aggregate impact value of coarse aggregates as per IS:2386(PartIV)-1963. In this study the Impact value was found to be 0.05%

Aggregate Crushing
Aggregates used in construction should be strong enough to resist crushing. If the aggregates are weak, the stability of the structure is likely to be adversely affected. The strength of coarse aggregates is assessed by aggregate crushing test. Aggregate crushing value (ACV) provide a relative measure of resistance to crushing under gradually applied

compressive load. Lesser the ACV stronger the given sample of aggregates. In this present study the aggregate crushing value was found to be 24.32%.

Sieve Analysis

Sieve analysis is used to determine the particle size distribution of a granular material.The size distribution is of critical importance to the way the material performs in use.In the present study the sieve analysis result shows that the aggregates are having size within the desired gradation.

Table 1: Results of Sieve Analysis

	% finer				
Sieve	20mm	10mm	Quarry dust	Obtained gradation	Desired gradation
19	67.75	100	100	100	100
13.2	9	99.85	100	87.2045	79-100
9.5	0	94.85	100	84.0945	70-88
4.75	0	9.45	100	52.4969	53-71
2.36	0	6.2	97	49.824	42-58
1.18	0	6.2	86	44.434	34-48
0.6	0	6.2	68	35.614	26-38
0.3	0	6.2	44	23.854	18-28
0.15	0	6.2	19	11.604	12-20
0.075	0	6.2	9.3	6.851	4-10

Shape Test

Shape test is used to determine the particle shape of the aggregate. The degree of particle packing of the particles of one size depends upon their shape. Flaky and elongated particles are considered undesirable for base coarse construction as they get easily break down under heavy loads.

Table 2: Results of Shape Test

	20mm	10mm
Flakiness index	6.94%	16.12%
Elongation index	17.93%	32.35%

Laboratory Test on Bitumen

There are many tests which are conducted to check the quality of bitumen. Bitumen is very important component of many construction sites like roads, highways. Basic test conducted on bitumen includes softening point test, ductility test and penetration test.

Table 3: Results of normal bitumen

S No	Experiments	Obtained result	Range
1	Penetration value	66.5	50-70
2	Softening point	44.5 degree Celsius	47degree Celsius
3	Ductility	75 cm	40cm

Tests Results of Bitumen with PG

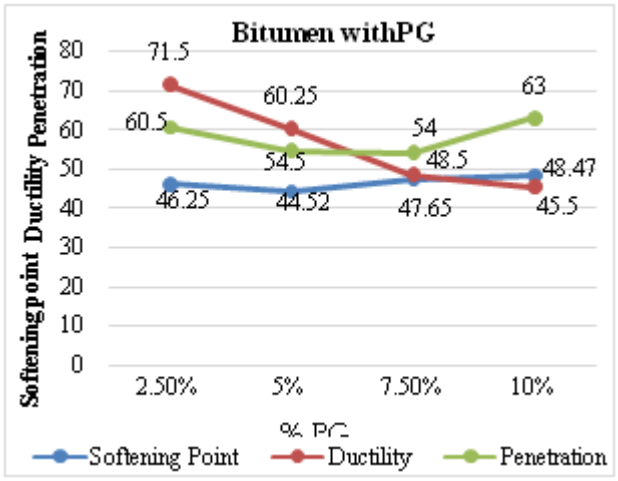

Figure 7: Comparison of basic properties of bitumen with PG

Softening point at 5% and 7.5% PG are 44.52 degreeCelsius and 47.65 degree Celsius respectively and this is within the range as per IRC specifications. Similarly for ductility at 5% and 7.5% are 60.25cm and 48.5 cm and both these values are greater than 40 cm as per IRC.

5. Tests Conducted On Bitumen With Plastic

Higher percentage plastic will lead to higher softening point. This may be due to chemical nature of polymers added. This increase in softening point shows that there will be less bleeding during summer. Bleeding accounts to increased friction for moving vehicles and also accounts for the slippery condition during rainy season. Both these adverse conditions are much reduced by polymer bitumen blend. Ductility decreased by addition of plastic to bitumen. This may be due to interlocking of polymer molecules with bitumen.

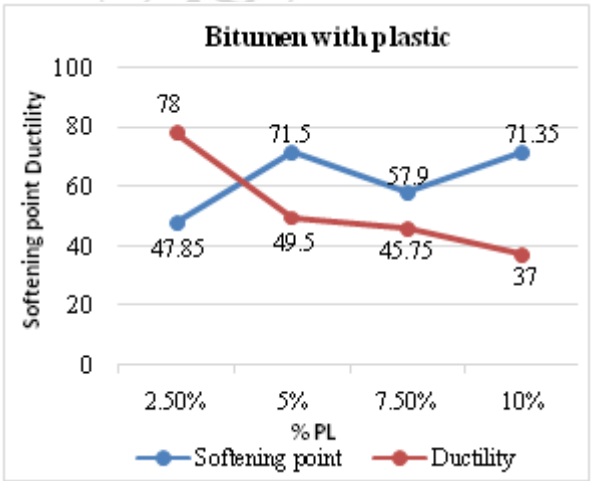

Figure 8: Comparison of basic properties of Bitumen with plastic

Softening point at 5% and 7.5% plastic are 71.5 degreeCelsius and 57.9 degree Celsius respectively and this is within the range as per IRC specifications. For ductility at 5% and 7.5% are 49.5cm and 45.75 cm and both these values are greater than 40 cm as per IRC.

Hence 5% and 7.5% of PG and Plastic are taken as optimum dosage of modifiers.

Determination of Optimum Bitumen Content (OBC)

OBC is the optimum bitumen content at which Marshall Stability value,bulk density are maximum and percentage air voids should be less than 4%. When Marshall Stability test was conducted for 5%,5.5% and 6% bitumen, it was found that OBC is at 5.5% bitumen.

OBC was found out from Marshall Stability test. Highest value of stability, Airvoids (4%) and maximum bulk density was obtained at 5.5 % bitumen content.

Table 4: Determination of OBC

% of bitumen	Marshall stability	Air voids	Bulk density
5	17.789	5.201	2.436
5.5	18.541	4.033	2.451
6	16.949	3.626	2.445

For Bitumen of VG-30, the optimum bitumen content obtained using marshal stability was found to be 5.5% from the above table.

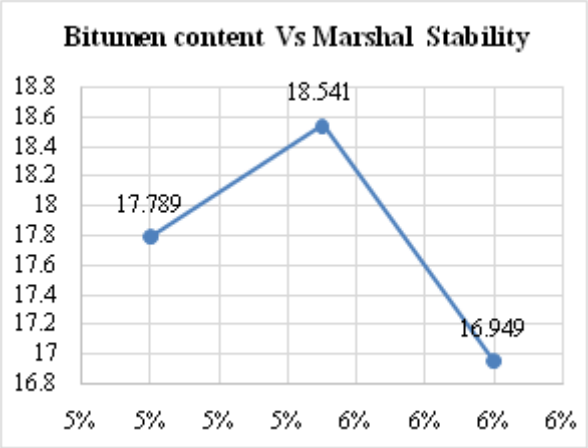

Figure 9: Determination of OBC

6. Comparative Study

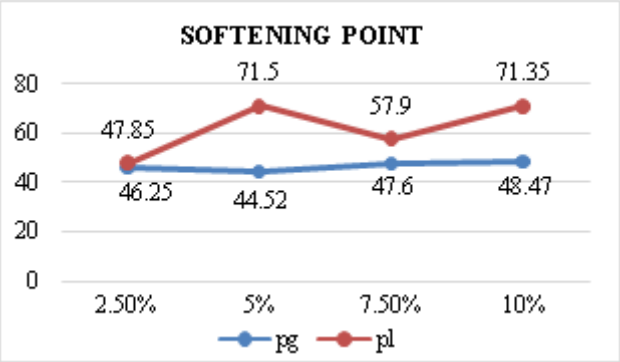

Figure 10: Comparison of Softening point of bitumen with modifiers

The test result shows the softening point of Plastic was higher than PG. Higher softening point indicates high temperature is required for melting of bitumen.

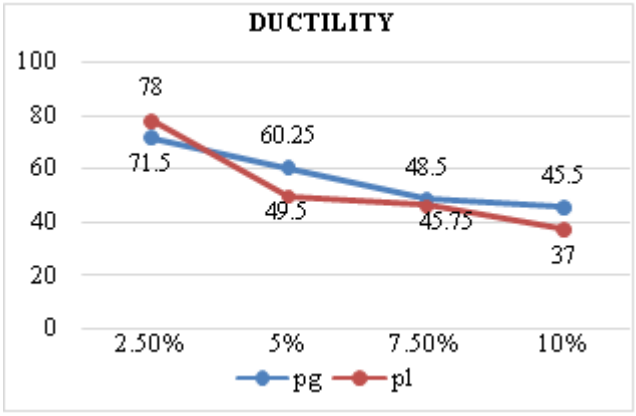

Figure 11: Comparison of ductility of bitumen with modifiers

Ductility of PLwas found to be lower than PG.PL makes the mix more stiff compared to PG.

Table 5: Comparison of volumetric properties of 5% and 7.5% of PG

Property	*Modified Bitumen with 5% PG*	*Modified Bitumen with 7.5 %PG*
Marshall Stability	17.557	19.076
Flow	5.25	5.5
Bulk Density	2.35	2.329
%Air Voids	7.988	8.823

Table 6: Comparison of volumetric properties of 5% and 7.5% of PL

Property	*Modified Bitumen with 5% PL*	*Modified Bitumen with 7.5% PL*
Marshall Stability	19.728	18.403
Flow	4.167	4.167
Bulk Density	2.308	2.271
%Air Voids	9.645	11.094

Optimum use of plastic can be done up to 5% based on Marshall Stability Test.Use of plastic material above 5% decrease the Marshall Stability.This can be attributed to poor adhesion between the mixture components due to the presence of coarse plastic particles. Better binding of bitumen with the plastic waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen.

Table 7: Comparison of volumetric properties of normal bitumen and 7.5% modified bitumen

Property	*Normal bitumen*	*Modified Bitumen with 7.5 %PG*	*Modified Bitumen with 7.5% PL*
Marshall Stability	18.541	19.076	18.403
Flow	4.433	5.5	4.167
Bulk Density	2.451	2.329	2.271
%Air Voids	4.033	8.823	11.094

Table 8: Comparison of volumetric properties of normal bitumen and 5% modified bitumen

Property	*Normal bitumen*	*Modified Bitumen with 5% PG*	*Modified Bitumen with 5% Plastic*
Marshall Stability	18.541	17.557	19.728
Flow	4.433	5.25	4.167
Bulk Density	2.451	2.35	2.308
%Air Voids	4.033	7.988	9.645

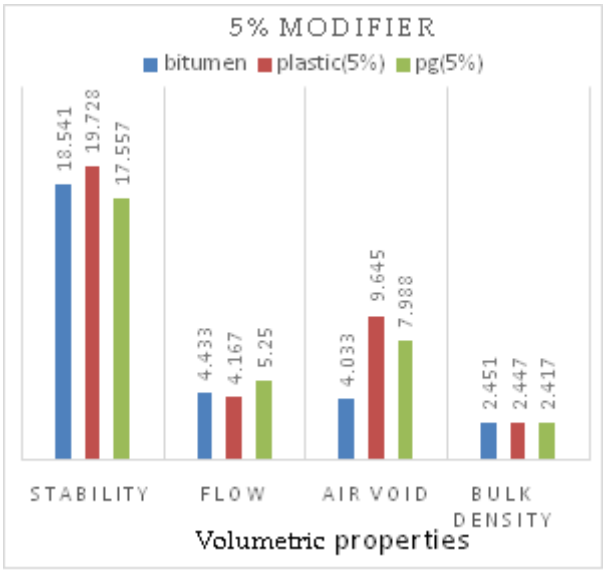

Figure 12: Comparison of volumetric properties with 5% modifier

Stability value was found to be maximum for plastic and it implies that it has more load carrying capacity compared to PG. While the flow value has decreased which indicates the deformation is less.

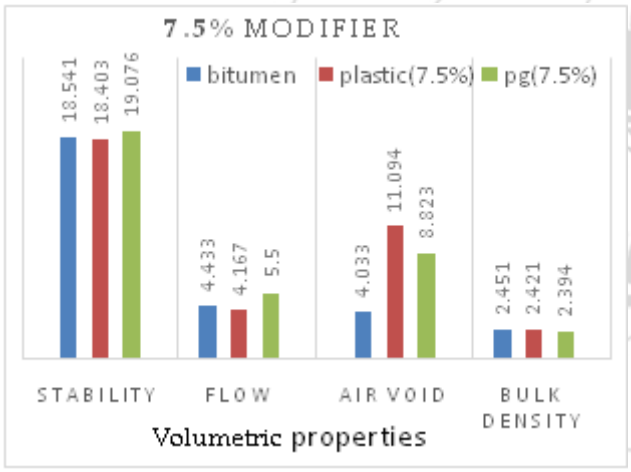

Figure 13: Comparison of volumetric properties with 7.5 % modifier

For PG the stability and flow value are higher than plastic and normal bituminous mix. While for plastic the flow value is less than PG though there is a slight decrease in stability value.

7. Conclusion

- Increase of waste plastic and waste phosphogypsum in bitumen increases the properties of bitumen.
- Use of waste plastic in flexible pavements shows good result when compared with conventional flexible pavements.
- Coating of polymer on the surface of the aggregate has resulted in many advantages, which ultimately helps to improve the quality of flexible pavement.
- Ductility for PL was maximum at 2.5% because plastic makes the bitumen stiff which reduces the plasticity.
- For PG, the marshal stability value has increased for 7.5%.Appreciatable change in property is brought about by increased PG content and hence their load carrying capacity.
- For PL, the marshal stability value is more for 5% than 7.5%.The marshal stability value for 7.5% PG and 5% PL is more compared to the marshal stability of normal bituminous mix.
- PG and PL has increased the load carrying capacity of the bituminous mix. Both PG and PL, are waste materials, the use of which has helped in improving marshal stability value.
- Polymer bitumen blend has increased softening point with suitable ductility value. When used for road construction it can withstand higher temperature. Hence suitable for tropical regions.
- After conducting Marshall Test, PG and Plastic has increased the load carrying capacity of the bituminous mix. Both PG and Plastic, are waste materials, the use of which has helped in improving marshal stability value.

8. Acknowledgement

This piece of work would never be accomplished without God almighty. For it is under his grace that I live, learn, and flourish. This report owes its existence to help, support and inspiration of my guide Ms. Amrutha S(Asst. Professor, Civil Dept.).She has been a constant source of enthusiasm and encouragement during the entire tenure of the project. I also owe this project report to my family members. Throughout all over endeavor's, their love, support, guidance and endless patience have truly inspirational.

References

[1] Sukaina Kazmi , Dubasi Govardhana Rao :'Efforts have been consistently made to find out the alternatives to dipose off the use plastic bags and materials',2015.
[2] Sandhya Dixit ,Prof.Deepak Rastogi :'Urgent need of alternate use of waste in bituminous mix to improve the properties of binder offers very promising alternative',2013.
[3] A U Ravi Shankar,K Kousik ,Gautham Sarang:'Modified bitumen is expected to give higher life of surfacing depending upon degree of modifications and type of additives ',2013.
[4] S Kamaraj,PK Jain,BM SharmaS Gangaopadhyay :'Essential to develop altenate bituminous mixes which are also high performance bituminious mixes',2013.
[5] P Paige-Green and S Gerber:'Experimental studies on uses of PG as a pavement material for roads ',2000.
[6] Manjunath K.R, Dheeraj Kumar N, Thippeswamy G.S:'Performance and Evaluation on Marshall StabilityProperties of Warm Mix Asphalt Using Chemical Additive', 2014
[7] Sasane Neha .B, Gaikwad.Harish, Dr. J R Patil and Dr. S D Khandekar,'Application of waste plastic as an effective construction material in flexible pavement',2015
[8] Dr. Hamed M. Jassim,Omar T. Mahmood, Sheelan A. Ahmed,'Optimum Use of Plastic Waste to Enhance theMarshall Properties and Moisture Resistance of

HotMix Asphalt; 2014 Avula Vamshi,'Use of waste plastic in construction of Bituminous road', 2013
[9] Dr. Abhaykumar S Wayal, Mudassir. D. Wagle,'Use of Waste Plastic and Waste Rubber in Aggregate and Bitumen for Road Materials',2013.
[10] Shweta n. rokdey ,'Useof plastic waste in road construction',2015
[11] Brightaforla anthony,'Assessment of suitability of plastic waste in bituminouspavement construction',2015